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$$\therefore I_{O_1}=\frac{\pi}{2}[\pi r^2R^3+\tfrac{5}{4}\pi r^4R+4r^3R^2+\tfrac{16}{15}r^5]$$

$$=\frac{\pi^2r^2R}{2}[R^2+\tfrac{5}{4}r^2]+[2\pi r^3R^2+\tfrac{8}{15}\pi r^5]\ldots(2).$$

It may be noted that (2) is equal to one-half the moment of inertia of the entire ring, plus the quantity $2\pi r^3R^2+\frac{8}{15}\pi r^5$. When, in this case, $R=0$, the outer portion evidently becomes a sphere of radius r, and I_{O_1} becomes $\frac{8}{15}\pi r^5$, or $\frac{2}{5}Mr^2$, where M is the mass of the resulting sphere. This, of course, is as it should be.

Similar computations for the inner portion of the ring give:

$$I_i=\frac{\pi^2r^2R}{2}[R^2+\tfrac{5}{4}r^2]-[2\pi r^3R^2+\tfrac{8}{15}\pi r^5]\ldots(3).$$

When $R=0$, the inner portion of the ring backs across the center, "turning wrong side out" in becoming a sphere, and its moment of inertia is $-\frac{8}{15}\pi r^5$, or $-\frac{2}{5}Mr^2$. It may be noticed that, when $R=0$, the value of I for the inner portion of the ring is the same as that for the outer portion, but with its sign changed. On comparing (2) and (3), it is seen that their sum is equal to (1) for $R>r$ and $R=r$, and that their sum is equal to zero when $R=0$. Between $R=r$ and $R=0$, equation (1) passes through a series of complications which are interesting, but perhaps more so to the mathematician than to the experimental physicist.

DEPARTMENTS.

SOLUTIONS OF PROBLEMS.

ALGEBRA.

365. Proposed by C. N. SCHMALL, New York City.

In still water, a steam tug goes 6 miles an hour less when towing a barge than when alone. Having drawn the barge 30 miles up a stream, whose current runs 1 mile an hour, it returns alone and completes the journey in 12 8/11 hours. Find the rate of the tug in still water.

Solution by MARY INGRAM, Lucus (Kansas) High School.

Let x=rate of the tug in still water; $x-7$=rate up stream with barge; $x+1$=rate down stream.

$\frac{30}{x-7}$=time up stream with barge; $\frac{30}{x+1}$=time in returning down stream alone.

$$\frac{30}{x-7}+\frac{30}{x+1}=12\tfrac{8}{11}=\tfrac{140}{11},$$

or, clearing of fractions, $330x+330+330x-2310=140x^2-840x-980$.

Whence, $7x^2-75x+50=0$, and therefore $7x=70$ or 5.

$x=10$ or $\frac{5}{7}$. $\frac{5}{7}$ is not admissible.

Also solved by M. A. Muzzy, A. H. Holmes, J. Scheffer, and H. C. Feemster.

366. Proposed by WILLIAM HOOVER, Ph. D., Professor of Mathematics and Astronomy, Ohio University Athens, Ohio.

Eliminate m from the equations

$$3a^2m^4+4aym^3+6axm^2-(x^2+y^2-4ax)=0;$$
$$(x^2+y^2-4ax)m^4-6axm^2+4aym-3a^2=0.$$

Solution by J. SCHEFFER, A. M., Hagerstown, Maryland.

Dividing the first equation by m^4, and adding, we get

$$4ay(m+\frac{1}{m})-6ax(m^2-\frac{1}{m^2})+(x^2+y^2-4ax)\ (m^4-\frac{1}{m^4})$$

and dividing this by $m+\frac{1}{m}$, we have

$$4ay-6ax(m-\frac{1}{m})+(x^2+y^2-4ax)\ (m^2+\frac{1}{m^2})\ (m-\frac{1}{m})=0.$$

Putting $m-\frac{1}{m}=p$, the last expression reduces to

$$4ay-6axp+(x^2+y^2-4ax)(p^2+2)p=0\ldots(\mathrm{I}).$$

Again dividing both of the original equations by m^2 and adding, we have

$$3a^2(m^2-\frac{1}{m^2})+4ay(m+\frac{1}{m})+(x^2+y^2-4ax)\ (m^2-\frac{1}{m^2})=0.$$

Suppressing the factor $m+\frac{1}{m}$, we get